NON-ROTATIONAL CASING HANGER AND SEAL ASSEMBLY RUNNING TOOL

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] This invention relates to an installation tool for landing a casing hanger in a wellhead and setting a seal assembly in the annulus between the casing hanger and wellhead in a single trip. The installation tool can perform these functions without requiring any rotation of the drill pipe string used for lowering the installation tool, casing hanger and seal assembly into the bore of a subsea wellhead.

[0002] The non-rotational casing hanger and seal assembly running tool of the present invention is used in oil and gas drilling operations of the type typically referred to as subsea. These type of oil and gas operations have a wellhead sitting on the ocean floor. As drilling operations proceed, various sizes of casing hangers will be lowered into the wellhead, each casing hanger having a length of casing threaded into to the lower end of the casing hanger. The lengths of casing typically will be from a few hundred feet in length for the larger size casings to several thousand feet of casing for the smaller sizes of casing. The casing hanger itself is a generally tubular member with a beveled outer shoulder sized to land on a mating inner shoulder in the wellhead or a previously installed casing hanger.

[0003] After each casing hanger and attached string of casing is landed in the wellhead a cement slurry is pumped through the casing hanger and casing. This cement slurry is forced to the bottom of the casing string where it then flows around the bottom end of the casing string and back up the annulus between the casing string and the drilled hole. After the cement has been placed, a seal assembly or packoff is lowered into the wellhead where it is urged into the annulus between the casing hanger and the inner wall or bore of the wellhead. The seal assembly often requires some mechanism to urge it into its sealed or energized position to ensure a positive seal in the annulus between the casing hanger and the inner wall or bore of the wellhead.

[0004] The seal assemblies used in this type of oil and gas drilling operations are typically either an elastomeric seal using the natural elasticity of a rubber compound to seal the annulus or a metal seal using a soft metal compound formed into a plurality of lips that are deformed or energized into contact with the bore of the wellhead and outside

diameter of the casing hanger to form the aforementioned annular seal. The metal seals require substantially more force to deform and energize them into their sealing configuration. Previous designs in the industry have either used torque or annulus pressure to energize these metal seals. Those designs utilizing torque have used rotation of the drill string to operate a threaded ring to apply the needed force. These designs have a couple of major limitations: it is difficult to determine how much of the applied torque is being applied to the threaded ring and how much of the torque is being expended in rotation of the long drill pipe string and the drag of the drill pipe string on the wellbore and as wellheads are deployed in ever greater water depths more of the applied torque is lost in the drag of the drill pipe string on the wellbore than is applied to the threaded ring. The previous designs using annulus pressure have been limited by the pressure that can be applied in the annulus between the inner and outer casing strings being sealed. This pressure limitation prevents enough pressure from being generated to generate the substantial force required to energize a metal seal.

[0005] Additionally, it is preferable if the tool used to lower the casing hanger and set the seal assembly in the casing hanger - wellhead annulus can accomplish these tasks in one trip. As wells are drilled in ever deeper water depths, the time for lowering a tool to the sea floor and retrieving it increases dramatically and this translates into higher drilling costs as the cost of the rig time required to perform these operations is high. It is therefore desirable to have an installation tool that can lower a casing hanger and associated seal assembly into a well bore, land the casing hanger, allow cementing and energize the seal assembly in a single trip without requiring rotation of the drill string. The non-rotational casing hanger and seal assembly running tool of the present invention offers a substantial improvement by offering a tool that can perform these functions in a single trip and allow testing of the installed seal assembly without requiring rotation of the drill striing.

2. Description of Related Art

[0006] U. S. Patent No. 4,903,776 to P. C. Nobileau et al. shows a casing hanger running tool using drill string tension to set the packoff. The axial movement of the drill string is used in conjunction with differential area pistons to apply force on a sleeve to set the packoff.

[0007] A casing hanger running tool using string weight is disclosed in U. S. Patent No. 4,928,769 to L. J. Milberger et al. This device also uses the weight of the drill string acting on differential area pistons to drive a setting sleeve downward to set the packoff.

SUMMARY OF THE INVENTION

[0008] The non-rotational casing hanger and seal assembly running tool of the present invention is designed for use in those subsea applications where non-rotation of the drill string is preferred or a requirement, i.e., primarily deep water applications or those involving reeled pipe installations. The non-rotational casing hanger and seal assembly running tool includes a mandrel having an upper end adapted for connection to a string of drill pipe and a bore therethrough. A tool body is carried by the mandrel and the mandrel and the tool body are axially moveable relative to one another.

[0009] The tool body includes a main body, an upper body and a lower body having a lower end adapted for connection to a string of drill pipe. The main body of the tool body supports a plurality of latching segments circumferentially spaced for releasably connecting the tool body to a seal assembly. A plurality of latching dogs are positioned circumferentially on the lower body of the tool body for releasably connecting the tool body to a casing hanger. The axial movement between the tool body and mandrel operates a pressure responsive shuttle piston positioned on the upper body to urge the seal assembly into the annulus between the casing hanger and a wellhead in which the casing hanger is landed.

[0010] The mandrel also includes a ball valve positioned in the mandrel bore that is operable between open and closed positions by axial movement of the mandrel relative to the tool body. The opening and closing of the ball valve allows independent operations to be carried out such as cementing the casing hanger in position through the mandrel bore and operating the shuttle piston to unlatch the tool from the casing hanger for retrieval.

[0011] A principal object of the present invention is to provide a seal assembly and casing hanger installation tool that can install a seal assembly and a casing hanger without requiring rotation of the drill pipe string used to lower the seal assembly and casing hanger to the subsea wellhead.

[0012] Another object of the present invention is to provide a seal assembly and casing

hanger installation tool that can install a seal assembly and casing hanger in a single trip.

[0013] A final object of the present invention is to provide a seal assembly and casing hanger installation tool that can perform the additional functions of cementing the casing hanger and perform pressure testing of the seal assembly after installation in a single trip.

[0014] These with other objects and advantages of the present invention are pointed out with specificness in the claims annexed hereto and form a part of this disclosure. A full and complete understanding of the invention may be had by reference to the accompanying drawings and description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] These and other objects and advantages of the present invention are set forth below and further made clear by reference to the drawings, wherein:

[0016] FIGURES 1A, 1B and 1C comprise a full sectional view of the installation tool for landing a casing hanger in a wellhead and setting a seal assembly in the annulus between the casing hanger and wellhead without requiring rotation of the drill pipe string of the present invention with a seal assembly secured on the installation tool and the installation tool lowered into a casing hanger.

[0017] FIGURES 2A, 2B and 2C comprise a half sectional view of the installation tool secured to the casing hanger by the latching dogs.

[0018] FIGURES 3A, 3B and 3C comprise a half sectional view of the installation tool during well bore cementing operations.

[0019] FIGURES 4A, 4B and 4C comprise a half sectional view of the installation tool as the seal assembly is urged into the annulus between the casing hanger and a wellhead housing.

[0020] FIGURES 5A, 5B and 5C comprise a half sectional view of the installation tool as the seal assembly is tested.

[0021] FIGURES 6A, 6B and 6C comprise a half sectional view of the installation tool as disengaged from the casing hanger, prior to retrieval to the surface.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] With reference to the drawings, and particularly to FIGURES 1A, 1B and 1C a

full sectional view of installation tool 10 for landing a casing hanger in a wellhead and setting a seal assembly in the annulus between the casing hanger and wellhead without requiring rotation of the drill pipe string of the present invention is shown. Installation tool 10 includes mandrel 12 with central bore 14 extending therethrough and tool body 16 carried on mandrel 12 and axially moveable relative to mandrel 12. Mandrel connector 18 is secured to the upper end of mandrel 12 by suitable connection means as threads 20. Mandrel connector 18 has internal drill pipe thread 22 formed at the opposite end for connection to a drill pipe string (not shown) that is used for lowering installation tool 10 to a wellhead positioned on the seafloor. Mandrel connector 18 is sealed to mandrel 12 by lip seals 24 adjacent threads 20.

[0023] The lower end of mandrel 12 has selectively operable closure means or ball valve 26 secured thereon by threads 28 and sealed by lip seals 30. Ball valve 26 has flow control member or ball 32 positioned in its central bore that is selectively operable by movement of ball pin 34. Movement of ball pin 34 rotates ball 32 between open and closed positions thereby opening and closing bore 14 of mandrel 12. Movement of ball pin 34 is controlled by the relative movement between mandrel 12 and tool body 16 in a manner to be described hereinafter.

[0024] Tool body 16 is composed of upper body 36, main body 38 and lower body 40. Upper body 36 is secured to the upper end of main body 38 by threads 42 and lower body 40 is secured to the upper end of main body 38 by threads 44. Upper body 36 forms piston 46 at its upper end with exterior seals 48 sealing on the interior of shuttle piston 50. Three sets of interior seals 52 are spaced axially along the interior of piston 46. The position of interior seals 52 relative to lateral port 54 in mandrel 12 controls the flow of pressurized drilling fluid from lateral port 54 to piston port 56 and thereby the movement of shuttle piston 50. The movement of mandrel 12 relative to upper body 36 opens and closes this passage. Lip seals 58 on the interior of annular shoulder 60 of shuttle piston 50 allow cycling of shuttle piston 50. In the initial running position shown in FIGURE 1, shuttle piston 50 is prevented from movement relative to upper body 36 by frangible connection means as tensile bolts 62, circumferentially spaced around upper body 36 in counterbore holes 64. Counterbore holes 64 are plugged with pipe plugs 66 to ensure the pressure integrity of piston 46.

[0025] Shuttle piston 50 is a generally cylindrical member with stepped outer shoulder 68 adjacent to interior annular shoulder 60. Lower skirt 70 extends axially downward from stepped outer shoulder 68. A plurality of flow ports 72 are circumferentially spaced around lower skirt 70 and allow drilling fluid to flow between the interior and exterior of shuttle piston 50. A plurality of laterally disposed and circumferentially spaced counterbore holes 74 are formed adjacent the lower end of lower skirt 70. Frangible connection means as shear bolts 76 are positioned in holes 74 and threaded into mating holes in actuator rod head 78. Actuator rod head 78 is an annularly shaped flange with a plurality of actuator rods 80 secured at its inner edge and circumferentially spaced. Actuator rods 80 extend axially from lower skirt 70.

[0026] Main body 38 of tool body 16 is secured to upper body 36 by threads 42 as noted above. Main body 38 is a generally cylindrically shaped member surrounding mandrel 12. Actuator rod holes 82 are formed at the upper end of main body 38 and aligned with actuator rods 80 when installation tool 10 is assembled. Positioned on the exterior of main body 38 are a plurality of connection means as latching segments 84 that are axially moveable in tracks 86 formed on the exterior of main body 38. Latching segments 84 are initially held in the up position of FIGURE 1 by frangible tensile bolts 88 extending through retainer flange 90. Retainer flange 90 is fastened to main body 38 by bolts 92, shown in FIGURE 2B, that are circumferentially spaced from tensile bolts 88. In the up, i.e., initial running position of FIGURE 1, latching segments 84 extend radially outward sufficiently to allow retainer lip 94 to engage the interior of seal assembly 96 and hold seal assembly 96 in place.

[0027] Seal assembly 96 is designed to effect a metal to metal seal in the annulus between the casing hanger and wellhead. Seal assembly 96 includes outer seal lips 98 and inner seal surfaces 100 that are urged into sealing engagement with the wellhead and casing hanger. Actuator ring 102 urges seal assembly 96 into its sealing position when acted upon by lower skirt 70 of shuttle piston 50. Lock ring 104 engages a complementary groove in the wellhead to lock seal assembly 96 in place.

[0028] Lower body 40 of tool body 16 is secured to main body 38 by threads 44 as noted above. Lower body 40 is a generally cylindrically shaped member surrounding mandrel 12. Apertures or windows 106 are formed at the upper end of lower body 40 and

evenly spaced around the circumference of lower body 40. Dogs 108 are disposed in windows 106 and include multiple shoulders 110 formed on their outer periphery. Dogs 108 are radially moveable and multiple shoulders 110 engage mating shoulders 112 in casing hanger 114 when installation tool 10 is landed in casing hanger 114. Casing hanger 114 is of the mandrel or shouldered type, with frustoconical outer shoulder 116 designed to land on mating shoulder 118 of previous casing hanger 120 which is landed in wellhead 122 (See FIGURE 3B). Frustoconical outer shoulder 116 has mud slots 124 formed in its outer periphery and evenly spaced circumferentially to allow drilling fluid to be circulated past casing hanger 114. The lower end of lower body 40 has drill pipe thread 126 formed thereon for connection to cementing equipment, well known to those of ordinary skill in the art.

[0029] Radial movement of dogs 108 is controlled by cam ring 128 positioned on mandrel 12. Cam ring 128 is initially retained by spring plunger 130, radially disposed in lower body 40. Cam ring 128 is aligned with actuator rods 80 through lower body 40 by alignment pin 132. Retrieval ring 134 is positioned near the upper end of cam ring 128 to ensure cam ring 128 is held in position during retrieval of installation tool 10.

[0030] The initial assembly of installation tool 10, seal assembly 96 and casing hanger 114 is shown in FIGURES 1 and 2. Seal assembly 96 is secured to the exterior of main body 38 as noted above and installation tool 10 is set in casing hanger 114 with dogs 108 retracted (FIGURE 1). Weight is set on mandrel 12 that overrides the detenting of spring plunger 130 and moves axially allowing cam ring 128 to urge dogs 108 radially outwardly and engage mating shoulders 112 in casing hanger 114 (FIGURE 2). Shuttle piston 50 is in its upward position and ball valve 32 is open. At this point, installation tool 10, seal assembly 96 and casing hanger 114 are lowered into wellhead 122.

[0031] As best seen in FIGURE 3, installation tool 10, seal assembly 96 and casing hanger 114 are landed in wellhead 122 with frustoconical outer shoulder 116 of casing hanger 114 setting on mating shoulder 118 of previous casing hanger 120. Although shown with casing hanger 114 sitting on previous casing hanger 120, it will be understood by those of ordinary skill in the art that casing hanger 114 could be landed on a mating shoulder (not shown) in wellhead 122, if appropriately sized, without departing from the scope of the present invention. Ball 32 is open and normal cementing operations are

carried out to cement casing (not shown) suspended from casing hanger 114 through central bore 14 of mandrel 12.

[0032] Referring to FIGURE 4, with cementing operations completed, weight is set on mandrel 12 to allow mandrel 12 to move axially relative to tool body 16. This causes ball pin 34 to close ball 32. Pressure is then applied through the drill string to bore 14 of mandrel 12. The axial movement of mandrel 12 causes lateral port 54 to align with piston port 56. Pressure applied in bore 14 acts through ports 54 and 56 and on top of annular shoulder 60 between exterior seals 48 and lip seals 58. This force breaks tensile bolts 62 and shuttle piston 50 can move axially. This axial movement of shuttle piston 50 allows lower skirt 70 to act on seal assembly 96 and actuator ring 102 and urge seal assembly 96 into its sealing position. Actuator ring 102 also moves lock ring 104 into a mating groove in wellhead 122 and locks seal assembly 96 in position. As seal assembly 96 is moved into position, latching segments 84 release seal assembly 96, and latching segments 84 move radially inwardly. Also, as shuttle piston 50 moves axially, shear bolts 76 are sheared and actuator rods 80 contacts cam ring 128 and retrieval ring 134 to lock them to mandrel 12.

[0033] Referring to FIGURE 5, pressure testing of seal assembly 96 is accomplished by applying pressure in the kill and choke lines (not shown) to apply pressure in the annulus between casing hanger 114 and wellhead 122 and on top of seal assembly 96. This pressure also serves to cycle shuttle piston 50 back to its initial (up) position. This is due to the force acting on the lower side of annular shoulder 60 between seals 48 and 58. Since shear bolts 76 are broken, actuator rod head 78 and actuator rods 80 are left in the lower position locking cam ring 128 and retrieval ring 134 to mandrel 12.

[0034] As best seen in FIGURE 6, once pressure testing is completed and it is desired to retrieve installation tool 10, tension is applied to mandrel 12. This tension on mandrel 12 and axial movement of mandrel 12 causes cam ring 128 and retrieval ring 134 to move with mandrel 12, thereby releasing cam ring 128 from behind dogs 108. Continued tension on mandrel 12, causes shoulders 110 on dogs 108 to cam against shoulders 112 on casing hanger 114 and urge dogs 108 radially inwardly in windows 106. Installation tool 10 can then be retrieved to the surface.

[0035] The construction of our seal assembly and casing hanger installation tool will be

readily understood from the foregoing description and it will be seen that we have provided a seal assembly and casing hanger installation tool that can install a seal assembly and a casing hanger without requiring rotation of the drill pipe string used to lower the seal assembly and casing hanger to the subsea wellhead. Furthermore, while the invention has been shown and described with respect to certain preferred embodiments, it is obvious that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of the specification. The present invention includes all such equivalent alterations and modifications, and is limited only by the scope of the appended claims.